California Regional Water Quality Control Board

Los Angeles Region

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SUBJECT: TECHNICAL COMPONENTS OF THE MUGU LAGOON SILTATION TMDL FOR CALLEGUAS CREEK

Introduction

This memorandum provides the basis for developing a Total Maximum Daily Load (TMDL) to address the beneficial use impairments of Mugu Lagoon by siltation. The siltation listing for Mugu Lagoon is included in Analytical Unit #5 of the Consent Decree between the United States Environmental Protection Agency (USEPA) and Heal the Bay, et.al. In addition to the siltation listing for Mugu Lagoon, Analytical Unit #5 contains listings for historic pesticides and sediment toxicity throughout the Calleguas Creek Watershed.

Most of the listings in Analytical Unit #5 are being analyzed by the Calleguas Creek Watershed Management Plan (CCWMP), in collaboration with the USEPA, and the Regional Water Quality Control Board, Los Angeles (Regional Board). However, the listing for siltation has not been addressed. Because USEPA is required to approve or establish a TMDL for the Mugu Lagoon siltation listing by March 2006, Regional Board staff analyzed relevant studies to develop load allocations and an implementation plan to address the siltation listing.

Problem Statement

Mugu Lagoon, located at the downstream end of the Calleguas Creek Watershed, was included on the 1998 303(d) list of water quality limited segments as impaired for sedimentation/siltation. The Regional Board staff recommended this listing as part of its 1995 survey of water assessment, based on the two studies summarized below:

- The US Department of Agriculture, "Calleguas Creek Watershed Erosion and Sediment Control Plan for Mugu Lagoon," 1995, which concluded "430 acres of lagoon intertidal salt marsh, approximately 40 percent, will be converted to upland habitat by the year 2030 (pg. viii)." It also documented a four-fold increase in sediment entering the lagoon following the expansion of urban and agricultural land uses in the Calleguas Creek Watershed.

- The 1993-1997 State Water Resources Control Board Bay Protection and Toxic Cleanup Program which found limited species quality and diversity among benthic species in Mugu Lagoon, in addition to sediment toxicity and surface water impairments. Among the bays and lagoons measured in Southern California, Mugu Lagoon was the only location with degraded benthic communities at every sample site.

This listing relates the loss of beneficial uses to elevated levels of sedimentation/siltation. Specific beneficial uses for Mugu Lagoon which may be impacted by sedimentation/siltation include Navigation, Non-contact Recreation, Commercial and Sport Fishing, Estuarine, Marine and Wildlife Habitat, Preservation of Biological Habitat, Rare, Threatened or Endangered Species Habitat, Migration of Aquatic Organisms, Spawning, Reproduction and/or Early Development and Shellfish Harvesting.

<u>Current Conditions</u>

The US Naval Base (Navy) at Mugu Lagoon completes biological studies of habitat extent and quality as defined in their Integrated Natural Resources Management Plan, 2002. The most recent survey was completed from airphotos (personal communication, 2004, M. Ruane, from US Navy Base Mugu Biological Survey 2000), and the results are summarized below.

A 1987 report by the Fish and Wildlife Service (Onuf, 1987) documented 1400 acres of habitat on the Naval Base.

Table 1: Mugu Lagoon – Acreage and Habitat Type

Habitat	**1987 Acreage (Onuf, 1987)**	**2000 Acreage (Navy, 2000)**
tidal marsh	905	46+782=828
Marsh transitioning to upland	0	270
tidal flat	128	346
salt pan	76	211
Subtidal channel/drainage	12	57
Subtidal ponds/open water	274	231
Ratio tidal marsh and flat to all other habitats	2.85	1.52
Total habitat	1395	1943

Sediment enters Calleguas Creek following erosion of approximately 340 square miles of watershed. While silt size particles (<.06 mm) may move under all flow conditions, larger particles will only move during flood flows. Further, while the particles larger than sand are readily deposited as floods ebb, the silt and clay particles may remain as suspended sediment throughout their transport to the ocean (Chang, 2004). A submarine channel outside the lagoon permanently funnels the suspended sediment to the seafloor through tidal, wave and stream actions (USDA, 1996). As a result, the volume of sediment entering the lagoon is larger than the volume deposited.

Annual measures of the sediment entering the lagoon vary widely as do short term estimates of deposition volume as shown below (USDA (1995), Chang (2004), RMA (2003)). The literature is difficult to interpret as wet and dry effects are often not quantified, the proportion of silt in the deposited sediment may not be specified and deposition volumes are usually inferred solely from incoming sediment volumes.

Table 2: Short term measures of siltation in Mugu Lagoon
for particles less than .06mm in Tons/Year

Reference*	**Supply to Lagoon**	**Deposition in Lagoon**
USDA, 1995 **	220,000	3,185 (if 30% silt)# 10,619 (if 97% silt)
USACE in Chang (2004)***	254,000 (if 30% silt) 849,000 (if 97% silt)	100,000 (if 30% silt) 357,000 (if 97% silt)
RMA study for USACE 2002	85,600	6,120 (all removed by later erosion)

** USDA study looked only at Calleguas and based sediment volumes on erosion by land use. They also predicted the change in the tidal prism, including its elimination within 25 years and recommended a minimum dredging volume to maintain existing conditions. This volume is assumed to be the annual loss of capacity. Siltation is calculated from this volume at 1000 kg/m3 (RMA, 2003) and various percentages of silt.
*** Army Corp's studies quoted in Chang 2004 looked at dredging and bathymetry information. Dredging volumes were based on flood control and construction requirement, not lagoon stabilization. The estimated loss of capacity assumes 1000 kg/m3 (RMA, 2003) and various percentage of fine material.
#Inman and Jenkins (1999) measured silt contents at the neighboring Santa Clara River with a low of 30% in the most extreme storms and higher levels of silt in the majority of discharges. For deposited materials this is projected to be the lowest percentage of silt. Chang (2004) estimates that deposition in Mugu Lagoon is 90% silt, but did not complete measurements.

Three longer-term estimates of sedimentation are considered more accurate in establishing the annual average rates of deposition. In the first estimate, Inman and Jenkins(1999) measured sedimentation volumes between 1944-1968. They reported an average volume of 6,210 tons/year, a measure that would include wet and dry conditions, specifies silt deposition, and was based on suspended sediment measures and lagoon geometry observation.

In the second estimate, RMA(2003) measured actual sediment deposition through changed bathymetery. RMA predicted 2 large storms and 2 moderate storms in ten years and quantified the deposition from storms in 1998. A total of 5,136 tons of silt (6% of the total sediment) was deposited outside the central channel during the large storms, 1,840 tons was deposited during the moderate storms and no deposition occurred between storms. Using Inman and Jenkins (1999) estimates that only 10% of the flood volume of fine material is transported in dry years, the measured deposition of 13,952 tons in the wet year, 1998, would be offset by 1,395 tons deposited in dry years. Further, if the proportion of wet to dry years is set, without the benefit of a rigorous analysis, at 3 wet years for every 7 dry years, a baseline for retained silt and clay over a decade of wet and dry years would be 5,162 tons per year.

A final estimate of long term sediment deposition can be completed using RMA's (2003) ten year bathymetric change model (Fig 4-20) which graphically displays 1,375,000 cubic feet of silt deposited in 10 years (about 2,750,000 square feet elevated an average of .5 feet) or 4,291 tons/year at 1000 kg/cubic meter.

Table 3: Long term values for Mugu lagoon sedimentation in tons/year silt and clay

Period	Tons/yr	Source
1944-1968	6,210	Inman and Jenkins (1999) sediment yield
Decade wet and dry	5,162	Inman and Jenkins 1999 TSS sampling and RMA sediment transport model
Decade wet and dry	4,291	RMA 2002 bathymetry model

Numeric Targets

The baseline for sedimentation comes from three estimates of deposition over ten to twenty-four years, showing averages from 4,291 to 6,210 ton/year accretion (an average of 5200 tons/yr.) as described above. The numeric target for siltation would be an annual average reduction of 5200 tons/year to prevent accretion or reduction in the area of the lagoon.

The numeric target for habitat would be the preservation of the 1995 value for marine/tidal habitat of 1400 acres. Evidence of habitat change from this value comes from a 2000 estimate of acreage distribution showing a 15% reduction in open water and a comparable increase in upland habitat at the expense of marine habitat over 15 years.

The habitat numeric target of 1400 acres habitat in the lagoon should be used unless a Science Advisory Panel replaces or expands this measure during the first eight years of the implementation plan. In addition, the annual numeric target calling for an average reduction in silt (i.e. washload) of 5200 tons/year at the entrance to the lagoon, should be assessed by the Science Advisory Panel, to ensure that it protects all beneficial uses in the lagoon.

Source Analysis

Estimations of sediment sources to Mugu Lagoon are summarized in the following table. These land uses were found to be associated with the highest amount of transport of sediment into the stream. The categories were identified as providing incremental contributions to the basin sediment total yield and as areas of potential sediment control.

Table 4: Top Five Sources of Sediment Yield to the Stream (USDA, 1995)

Sediment yield to stream	Land Use	Tons/Year
1	Streambanks	152,000
2	Orchards	74,000
3	Construction	53,000
4	Natural areas	45,000
5	Other roads	23,000

Linkage Analysis

Inman and Jenkins (1999) showed a five-fold fluctuation in sediment volume as a function of precipitation, and demonstrated higher sediment delivery in the 1980's than in the 1940's. The USDA report (1995) confirmed the higher rates of recent sediment delivery (Table 6) in one subwatershed of the Calleguas watershed selected as typical but not averages.

Table 5: Sources of Erosion over Time in Grimes Canyon based on Land Use (USDA, 1995)

Period	Tons/year
Native American Period	1392
Spanish/Mexican Period	2297
Expansion of Agriculture (1932)	13,960
Current Period	15,170
Buildout Conditions	13,541

The 2003 RMA study shows that increased sediment accumulation may occur in parts of Mugu Lagoon over the next decade in areas that currently contain habitat. The accumulation would on average be equal to or less than 0.6 feet, while mudflat (saltmarsh) areas may gain 0.4-1.2 feet, and localized deposition in some areas may be greater than 1 foot. The specific impact of the elevation change on salt and estuarine marshes and tidal flats was not evaluated. The RMA study also modeled the movement of fine material throughout the lagoon, showing widespread silt deposition during storm events. The study speculated that this material was removed by tide and wave effects.

The recommendations for silt reduction reported in the literature vary widely. RMA (2003) recommended no reduction, despite predicting elevation changes for habitat and 6,012 tons of silt deposition in a single storm. The USDA (1999) recommended reductions up to 254,000 tons/year. Their smallest proposed change was for 3,185 tons per year for dredging to retain the existing tidal prism. Chang (2004) proposed as large a reduction as 357,000 tons/year by creating a diversion canal, which would deprive the lagoon of all Calleguas Creek sediment. Ventura County Watershed Protection District staff currently believe that additional sediment should be added to a lagoon (VCWPD, personal communication, 2005) which is experiencing silt starvation.

Land use studies completed by the USDA (1995) quantify the volume of sediment supply from each subwatershed. A 5200 ton/year reduction could be proportionally distributed to each of the subwatersheds described in the 1995 USDA report based upon the percentage of the washload, which ranges from 863 tons/mile for Arroyo Las Posas to 10 tons/mile for Long Grade Canyon. These estimates show the magnitude of management change necessary for each area of the watershed. The USDA (1995) study also includes discussion of specific practices and the volume of total sediment reduction to be expected.

The silt reduction is unlikely to be measured by weight in the upper portions of the watershed. Instead, measurement by total suspended solids (TSS) is standard. A rating curve relating TSS to discharge at the entrance to Mugu Lagoon is expected to be available from the Navy during the first year of the implementation plan, providing a method to relate discharge and measured TSS to tons of sediment transported and allow an easier quantification of the numeric target.

The RMA (2003) does include a rating curve for TSS that demonstrates that this measure, if accompanied by discharge information, can provide sufficiently accurate estimates of silt transport. Specifically, the February 23-24, 1998 storm delivered discharges of 15,000 cfs for about 3 hours at the entrance to Mugu Lagoon. The USGS rating curve quoted predicts TSS values of 18000 mg/L at that discharge at the nearby University gauging station. These values predict that 91,020 tons of total suspended solids entered the lagoon. The RMA study report confirms the accuracy of the method in reporting that 85,600 tons of silt entered the lagoon during this event.

<u>Critical Conditions</u>

The US Army Corp/RMA 2003 study found that little sediment enters the Lagoon during typical (dry weather) conditions. This is in contrast to storm conditions when 10-13% of the incoming sediment was deposited and the remainder transported to the ocean. While dry conditions may be more important for the creation of habitat, storm conditions would have a greater effect on their erosion. A TMDL, which requires retention of average habitat acreage and distribution and assessment of habitat impacts with changing sedimentation rates, considers both critical conditions of wet and dry.

Margin of Safety

The implicit margin of safety is based on conservative estimates of sediment volume reduction and preservation or gradual habitat improvement.

Table 6: Assumptions in Implicit Margin of Safety

Technical Component	Measure	Margin of Safety
Implementation Plan	Source reduction and habitat studies	1)Because significant differences of technical opinion exist as to the relationship between siltation and habitat health, an adaptive management strategy is laid out in the implementation plan, with possible changes in the sediment supply and a measurement of the impact on habitat, upon which the beneficial use impairment is based.
Silt numeric target	5200 tons/year reduction	(a)Change is 1% or less of maximum measured sediment supply, so too much reduction not likely (b)Change is based on loss of capacity not sediment supply
Habitat acreage numeric target	1400 acres	(a)Already exceeded in 2000 Navy estimate (b)To be evaluated and/or modified by Science panel (c)Based on assessment of independent agency (Fish and Wildlife)
Silt numeric target	TSS measure of reduction	(a)Rapid and common measure allows multiple assessments of sedimentation change. (b)TSS measures less accurate in low flow conditions, and more reliable in flood, when reductions are expected.
Silt reduction in subwatersheds	% of 5200 tons/year, which varies from 104 to 2236 tons/year	(a)Based on State funded and exhaustive study of subwatersheds which includes a more accurate sediment supply than usually available.

Allocations

Agricultural dischargers will receive an allocation of 5,200 tons/yr. reduction in sediment yield to Calleguas Creek, which may be achieved through management practices such as sediment basin construction, grade stabilization, replanted orchard, creation of riparian habitat, road redesign, bank protection, orchard cover crop, and filter strip implementation (USDA, 1995). These practices are implemented through the Total Suspended Solids (TSS) water quality objective measured for the Conditional Waiver for Irrigated Lands, the sediment reduction levels which may meet the load allocations for the Historic Pesticides and PCB TMDL for Calleguas Creek, and the requirements of this document.

The PCB and Toxicity TMDLs both include implementation measures to reduce toxic sediment movement into Calleguas Creek. In addition, both report extensive contamination of sediment, especially on agricultural land. The management of sediment discharge from agricultural lands during TMDL implementation is expected to commence in 2006. The management changes should reduce the concentration and toxicity of these sediments by increasing the relative proportion of the clean upland sediments.

Specifically, the maximum TMDL sediment reductions are given below, with a measure of the predicted tons/year change and the percentage recommended in this document to protect Mugu Lagoon.

Table 7: Sediment Reduction Allocation Amounts

Sub watershed*	Silt supply*	Percent of total supply*	Silt reduction by % of total	Percent sediment reductions from pesticide TMDL
Mugu	4000 tons	2%	104 tons	97%
Calleguas	6000 tons	3%	156 tons	96%
Revolon + Beardsley	47,000 tons	26%	1352 tons	98%
Arroyo Las Posas	77,000 tons	43%	2236 tons	98%
Arroyo Simi	23,000 tons	13%	676 tons	0%
Conejo Creek	24,000 tons	13%	676 tons	0%
Total	181,000 tons		5,200 tons	

USDA, 1995*

Storm water/construction dischargers/401 applicants will receive an allocation of 1% washload/silt reduction per year from the amount measured in the year of TMDL adoption. The objective of the allocation is not to cause a decrease in sediment supply, but to maintain the current sediment production levels from these sources. As an example, 401 applications, dredging plans or construction design, which result in a large change in sediment supply, could be contraproductive to the goals of the TMDL.

Implementation Plan

(1) Year 1:

Special Studies: Convene a Science Advisory Panel, to be approved by the Executive Officer, to evaluate the effectiveness of all Calleguas TMDL siltation load allocations in protecting the beneficial uses of Mugu Lagoon. Science Advisory Panel will evaluate the historic and current habitat in Mugu Lagoon, and recommend a biological and habitat condition to protect habitat related beneficial uses. Study will include, but not be limited to, evaluation of appropriate habitat baseline, effectiveness of siltation load allocations on a subwatershed basis, methods to restore habitat, and effectiveness of load allocated on a subwatershed basis, if required.

(2) Year 2-8:

Special Studies-Continued: The Science Advisory Panel shall oversee the preparation of a workplan, to be approved by the Executive Officer, to commence studies to meet the requirements described above. This study may include bathymetry studies, silt and flow sampling, surface water chemical analyses, measures of sediment toxicity and measures of benthic quality of sufficient detail to allow comparison with the Bay Protection and Toxic Cleanup assessment completed in 1998. The workplan will include sufficient detail, and will include a status report due 5 years after adoption, such that the Regional Board may use the findings to evaluate the need for a TMDL based on the listings in Analytical Unit #8 for pesticides in the vicinity of the Rio De Santa Clara and Oxnard Drain #3, which lie on the Navy Base. Annual status reports will be provided to the Regional Board. Final report due 8 years after the effective date of the TMDL.

(3) Year 13:

Establish load allocations: The Regional Board may revise targets and allocations for siltation in Mugu Lagoon and the subwatersheds of the Calleguas Watershed based on the numeric targets presented or new allocations recommended by the Science Advisory Panel within 8 years of the effective date of the TMDL. Responsible parties are agricultural users, the US Naval Base, MS4 permitees, Ventura County Watershed Protection and other stakeholders who may be identified.

Alternatives Considered:
The Regional Board considered eight sediment TMDLs on the US EPA website as protoypes for this study. The Garcia River and Navarro River TMDLs used tons/mile/year as the numeric target

to achieve in-stream conditions supportive of salmon habitat and wasteload allocation were based on land use. The Little Arkansas River used a mg/L total suspended solid and % EPT, a measure of biological diversity derived from macroinvertebrate studies. The Newport Bay TMDL used a sediment production and transport model to identify a numeric target in tons/year which reflects the excess amount of sediment moving through the system. The waste load allocations were in tons/year/area as a percent reduction by sediment supply area. This TMDL for Mugu Lagoon is in accordance with existing sediment TMDLs.

Attachment 1
State and Federal Examples of wetlands/lagoon habitat classification systems

(1)Draft California rapid assessment model for wetlands v. 3 Sept. 30,2004
size
connectivity
percentage with buffer
width of buffer
buffer condition
water source
hydro period
hydrologic connectivity
physical patch richness
topographic complexity
organic matter accumulation
biotic patch richness (species dependent)
vertical biotic structure
percent invasive plant species
stressors

(2)USEPA Review of Rapid Methods for Assessing Wetland Condition January 2004
(choose from 7 of 40 complete state methods. Some common elements listed below)
size
hydrogeomorphic/wetland type
stressors
hydrology
soils
biotic communities
services and values

(3)SWRCB BPTC Sediment Chemistry, Toxicity, and Benthic Community Conditions in selected water bodies of the Los Angeles Region August 1998
Chemistry of surface water by PEL TEL
Sediment toxicity (13 species by student t test and MDL)
- bioaccumulation in mussels
- amphipod survival
- abalone embryo-larval development
- worm survival and growth
- sea urchin larval development/fertilization

Relative Benthic Index
- Number of species
- Number of individuals
- Positive Indicators
- Negative Indicators

Reference Conditions
Sediment Triad (chemical pollution, benthic community structure, species toxicity)

Attachment 2
References

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